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Use of nuclear power sources in outer space

Convention on Nuclear Safety and the Safety Fundamentals of the International Atomic Energy Agency: a common approach to the safety of terrestrial nuclear power sources

Working paper submitted by the United Kingdom of Great Britain and Northern Ireland

1. In its report to the Scientific and Technical Subcommittee at its thirty-seventh session, the Working Group on the Use of Nuclear Power Sources in Outer Space agreed that a detailed examination of the Convention on Nuclear Safety[1] and the related International Atomic Energy Agency (IAEA) documents, particularly the Safety Fundamentals, should be undertaken within the framework of the second year of its work plan. The objective of this working paper is to review the historical development of the above-mentioned documents to show how they came about and how they contribute to a common international approach to the safety of terrestrial nuclear power sources. The framework provided by this common approach allows individual countries to demonstrate their adherence to agreed nuclear safety objectives while still following, at a detailed level, the individual national standards that are required by their own laws and industrial practices.

2. The present document is intended to be complementary to the report by IAEA (A/AC.105/754) containing a preliminary review of various international documents that might be relevant to the safety of nuclear power sources in outer space, in particular binding international conventions and the IAEA safety standards. The aim of both documents is to provide information for further discussions of the Scientific and Technical Subcommittee and the Working Group on the Use of Nuclear Power Sources in Outer Space.

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I. Background

3. The Convention on Nuclear Safety was a direct consequence of the Chernobyl nuclear accident in 1986. In the aftermath of the accident, nuclear operators and regulators around the world had to expend considerable effort in reassuring their Governments, parliaments and the general public about:

(a) The immediate radiological implications of the event;

(b) The implications for their plants of the design aspects of the channelized large power reactor (RBMK) plant that contributed to the event;

(c) The effectiveness and efficiency of the various international agreements on early notification and assistance in the case of such a nuclear accident;

(d) The coherence and harmonization of the nuclear safety standards that applied to terrestrial nuclear power plants worldwide;

(e) The implications for their organizations of the perceived deficiencies in safety culture and safety management that contributed to the event.

Each of these aspects presented considerable challenges to the global nuclear community, but the present paper concentrates on the last two, as they may be of the greatest relevance to nuclear power sources in outer space.

4. One of the most significant political reactions to the Chernobyl accident, especially in neighbouring countries such as Germany, was to query the extent to which nuclear power plants worldwide were required to meet a consistent standard of safety. Nuclear operators and regulators were, of course, able to point to the existing IAEA Safety Series publications, such as the Nuclear Safety Standards (NUSS) Codes and Safety Guides, as demonstrating the degree of consensus that existed internationally at the detailed technical level. However, there was no overarching document to the NUSS Codes and Safety Guides, so the IAEA Nuclear Safety Standards Advisory Group[2] decided, in 1990, to produce a set of safety fundamentals. That resulted in a consensus document on the top-level safety fundamentals for nuclear installations, which was issued as Safety Series publication No. 110[3] in July 1993.

5. The international community was also aware that there was no general binding international convention on nuclear safety. So, at the IAEA General Conference in September 1991, it was agreed that consultations should be carried out about the possibility of such a nuclear safety convention. After two and a half years of intense negotiation, the Convention on Nuclear Safety was adopted on 17 June 1994 by a Diplomatic Conference convened by IAEA.

II. Convention on Nuclear Safety

6. Two of the main driving forces behind the Convention on Nuclear Safety, namely the Chernobyl accident and the lack of a harmonized set of international safety standards for nuclear power plants are clearly seen in the preamble to the Convention, which refers to the contracting parties as being:[1]

"Aware of the importance to the international community of ensuring that the use of nuclear energy is safe, well regulated and environmentally sound;

"...

"Aware that accidents at nuclear installations have the potential for transboundary impacts;

"...

"Recognizing that this Convention entails a commitment to the application of fundamental safety principles for nuclear installations rather than of detailed safety standards and that there are internationally formulated safety guidelines which are updated from time to time and so can provide guidance on contemporary means of achieving a high level of safety".

7. The preamble also makes specific reference to the concept of "safety culture":[1]

"Desiring to promote an effective nuclear safety culture".

8. So, right from the outset, the Convention makes it clear that contracting parties will be committing themselves to applying common fundamental safety principles rather than detailed standards, and it draws specific attention to the importance of safety culture in avoiding nuclear accidents.

Chapter 1. Objectives, definitions and scope of application

9. From the point of view of the United Kingdom of Great Britain and Northern Ireland, the two most important things to note in chapter 1 of the Convention[1] are the objective "to achieve and maintain a high level of nuclear safety worldwide through the enhancement of national measures and international co-operation including, where appropriate, safety-related technical co-operation", and the restriction of the Convention's application to land-based civil nuclear power plants.

Chapter 2. Obligations

10. Chapter 2 contains most of the "meat" of the Convention, including obligations on each contracting party:[1]

(a) To submit, for peer review, a report on the measures it has taken to implement each of the obligations of the Convention;

(b) To ensure that the safety of existing nuclear installations is reviewed as soon as possible and, when necessary, that all reasonably practicable improvements are made as a matter of urgency to upgrade the safety of such nuclear installations. If such upgrading cannot be achieved, plans should be implemented to shut down the nuclear installation in question as soon as practically possible;

(c) To establish and maintain a legislative and regulatory framework that shall, inter alia, provide for a system of licensing and the prohibition of the operation of a nuclear installation without a licence;

(d) To establish or designate a regulatory body and take the appropriate steps to ensure an effective separation between the functions of the regulatory body and

those of any other body or organization concerned with the promotion or utilization of nuclear energy;

(e) To take the appropriate steps to ensure that the capabilities and limitations of human performance are taken into account throughout the life of a nuclear installation;

(f) To take the appropriate steps to ensure that the radiation exposure to the workers and the public is kept as low as reasonably achievable and that no individual is exposed to radiation doses which exceed prescribed national dose limits;

(g) To take the appropriate steps to test emergency planning arrangements and provide relevant information to its own population and the competent authorities of the States in the viewing of the nuclear installation (contracting parties which do not have a nuclear installation on their territory are, nevertheless, obliged to take the appropriate steps to prepare and test emergency plans for their territory if they are likely to be affected by a radiological emergency at a nuclear installation in the vicinity);

(h) To take the appropriate steps to ensure that programmes to collect and analyse operating experience are established, the results obtained and the conclusions drawn are acted upon and that existing mechanisms are used to share important experience with international bodies and with other operating organizations and regulatory bodies.

Chapter 3. Meetings of the Contracting Parties

11. A novel feature of the Convention is its use of peer review procedures to encourage contracting parties to pursue agreed nuclear safety objectives. Thus there are obligations on the contracting parties:[1]

(a) To hold meetings, at an interval not to exceed three years, to review the reports on the measures they have taken to implement their obligations under the Convention;

(b) To allow other contracting parties a reasonable opportunity to discuss their reports and to seek clarification of the reports;

(c) To adopt, by consensus, and make available to the public a document addressing issues discussed and conclusions reached during a meeting.

12. One of the most challenging tasks for the contracting parties was to prepare and adopt appropriate rules of procedures for the peer review meetings. With over 50 contracting parties, it was clearly going to be impossible (financially and administratively) to allow each contracting party the opportunity to review the reports of every other (relevant) contracting party. In the end, it was decided to divide the contracting parties into six country groups, each group including countries with nuclear power programmes of different sizes, as well as countries not having nuclear power reactors. Each group was responsible for reviewing the reports submitted by its members and providing a synthesis report to the general meeting of the parties. At that meeting, the group reports were presented by a

rapporteur, who dealt with general questions relating to criteria used, safety levels achieved etc.

13. The first review meeting took place in April 1999. Further developments will be necessary in the procedures for producing national reports and for reviewing them. However, all parties agreed that the process of preparing the initial reports had created a valuable "benchmark" regarding the status of nuclear safety in virtually all nations utilizing nuclear power. The benchmark will be invaluable in assessing future progress in enhancing nuclear safety worldwide.

III. The Safety of Nuclear Installations

14. In the foreword of *The Safety of Nuclear Installations*,[3] it is explained that that Safety Fundamentals publication presents an international consensus on the basic concepts underlying the principles for the regulation, management of safety and operation of nuclear installations. It forms a top-level publication in the hierarchy of the IAEA Safety Series. The publication explains the basis for the detailed and technically complex measures taken to ensure nuclear safety and provides an insight for those who make decisions related to the use of nuclear energy but who may not be specialists in nuclear science and technology. It is thus one of the fundamental supporting documents of the Convention on Nuclear Safety.

15. The layout of the publication is very similar to that of the Convention, comprising:[3]

(a) *Introduction*. The introduction explains where the publication fits into the IAEA Safety Series publications; defines its objective ("to define those fundamental safety principles which, when effectively applied, contribute to the reduction to very low levels of any detrimental effects from the use of nuclear technology"); explains its scope ("These principles, since they are fundamental in nature, are applicable to a broad range of nuclear installations, ..."); and defines its structure;

(b) *Safety objectives*. There is a general nuclear safety objective ("to protect individuals, society and the environment from harm by establishing and maintaining in nuclear installations effective defences against radiological hazards") which is supported by a radiation protection objective ("to ensure that in all operational states radiation exposure within the installation or due to any planned release of radioactive material from the installation is kept below prescribed limits and as low as reasonably achievable, and to ensure mitigation of the radiological consequences of any accidents") and a technical safety objective ("to take all reasonably practicable measures to prevent accidents in nuclear installations and to mitigate their consequences should they occur; to ensure with a high level of confidence that, for all possible accidents taken into account in the design of the installation, including those of very low probability, any radiological consequences would be minor and below prescribed limits; and to ensure that the likelihood of accidents with serious radiological consequences is extremely low");

(c) *Legislative and regulatory framework*. The three principles in this area deal with:

(i) Establishing the framework: "The government shall establish a legislative and statutory framework for the regulation of nuclear installations. There shall be a clear separation of responsibilities between the regulatory body and the operating organization";

(ii) Safety responsibility: "The prime responsibility for safety shall be assigned to the operating organization";

(iii) Regulatory independence: "The regulatory body shall be effectively independent of the organization or body charged with the promotion or utilization of nuclear energy. It shall have licensing, inspection and enforcement responsibilities and shall have adequate authority, competence and resources to fulfil its assigned responsibilities. No other responsibility shall jeopardize or conflict with its responsibility for safety";

(d) *Management of safety.* The five principles in this area deal with:

(i) Management structures for safety: "Organizations engaged in activities important to safety shall establish policies that give safety matters the highest priority, and shall ensure that these policies are implemented within a managerial structure having clear divisions of responsibility and clear lines of communication";

(ii) Quality assurance programmes: "Organizations engaged in activities important to safety shall establish and implement appropriate quality assurance programmes which extend throughout the life of the installation, from siting and design through to decommissioning";

(iii) Staffing and training: "Organizations engaged in activities important to safety shall ensure that there are sufficient numbers of adequately trained and authorized staff working in accordance with approved and validated procedures";

(iv) Human performance: "The capabilities and limitations of human performance shall be taken into account at all stages in the life of the installation";

(v) Emergency preparedness: "Emergency plans for accident situations shall be prepared and appropriately exercised by all organizations concerned. The capability to implement emergency plans shall be in place before an installation commences operation";

(e) *Technical aspects of safety.* There are 15 principles dealing with siting; design and construction; commissioning; operation and maintenance; and radioactive waste management and decommissioning. These are rather specific to terrestrial nuclear installations and not of direct interest to nuclear power sources in outer space.

(f) *Verification of safety.* There are two principles: "The operating organization shall verify by analysis, ..., testing and inspection that the physical state of the installation and its operation continue in accordance with operational limits and conditions, safety requirements and the safety analysis"; and "Systematic safety reassessments of the installation in accordance with the regulatory requirements shall be performed throughout its operational lifetime, with account

taken of operating experience and significant new safety information from all relevant sources."

IV. Conclusions and recommendations

16. The Chernobyl accident was a salutory experience for the operators and regulators of nuclear power stations worldwide. Faced with some rather basic questions about the safety standards that different countries applied and the extent to which they were harmonized, the global nuclear community realized that it lacked a proper framework for expressing the levels of safety that it was confident were being achieved in properly operated and regulated nuclear power plants. The IAEA Safety Series publications were excellent statements of the international consensus in a wide range of detailed safety-related areas, but they had evolved as the industry had developed, in a rather haphazard way. It was recognized that what was lacking was a framework to explain how those internationally agreed consensus documents dovetailed with the individual national rules, standards and regulations that each country was legally obliged to apply to its own nuclear power industry. Above all, it was realized that there needed to be a statement of the general safety principles that all nuclear power plants should meet and a mechanism for demonstrating that individual countries were complying with those principles. The Convention on Nuclear Safety and the IAEA Safety Fundamentals provide the necessary commitment, framework and procedures for achieving those aims.

17. It is recommended that the lessons learned, and the international framework developed, by the global nuclear power community should be examined closely to see what implications they may have for the use of nuclear power sources in outer space. That will illustrate the value that a proper framework of international commitments, top-level principles and more detailed standards can contribute to political and public discussions and inquiries in the event of an accident or if any significant expansion in relevant nuclear activities is contemplated.

Notes

[1] International Atomic Energy Agency, "Convention on Nuclear Safety" (INFCIRC/449), annex.

[2] Now called the Nuclear Safety Standards Advisory Committee.

[3] *The Safety of Nuclear Installations*, Safety Series No. 110 (Vienna, International Atomic Energy Agency, 1993).

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Examination of the physical nature and technical attributes of the geostationary orbit and of its utilization and applications, including, inter alia, in the field of space communications, as well as other questions relating to developments in space communications, taking particular account of the needs and interests of developing countries

Status of work on electromagnetic interference and radio astronomy

Information submitted by the secretariat of the Organisation for Economic Cooperation and Development

At their meeting in June 1999, the ministers of science of the member States of the Organisation for Economic Cooperation and Development (OECD) recognized that the future of radio astronomy would be strongly affected by electromagnetic emissions from low-orbiting telecommunications satellites. They agreed on the need for innovative measures to protect that fascinating field of scientific research while allowing for the vigorous growth of the communications industry. They endorsed a plan to bring together leaders in the domains of industry, science and regulation, in order to engage in constructive, informal discussions that could produce new guidelines, principles and proposals that, in turn, could be followed up by the appropriate technical, legal and regulatory bodies. Following the ministerial meeting, the OECD secretariat began working with the delegations of member States to establish a task force on radio astronomy and the radio spectrum. That work is essentially complete, and OECD will soon announce the creation of the task force, which is to hold its first meeting during the first quarter of 2001. The task force will define the scope of its work and develop a time line and work plan based on the types of outcome that it will try to achieve.

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